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THE PANAMA CANAL

HANDBOOK  
FOR EMPLOYEES OF THE  
ELECTRICAL DIVISION

THE PANAMA CANAL ZONE  
GENERAL INFORMATION  
1916



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THE PANAMA CANAL. Dept. of  
operation and maintenance.

Handbook for Employees  
of the  
Electrical Division

THE PANAMA CANAL PRESS  
SUPPLY DEPARTMENT  
MOUNT HOPE, C. Z.

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NOTE.

This booklet is compiled for the convenience of employees of the Electrical Division. It contains an outline of the Cost Keeping System, Electrical Circulars and Rates, some instructions to wiremen, etc., a list of Electrical Division forms, and a few tables which it is hoped will be of some assistance in the field. Revisions may be made and suggestions of value will be used.

*October 1, 1916.*

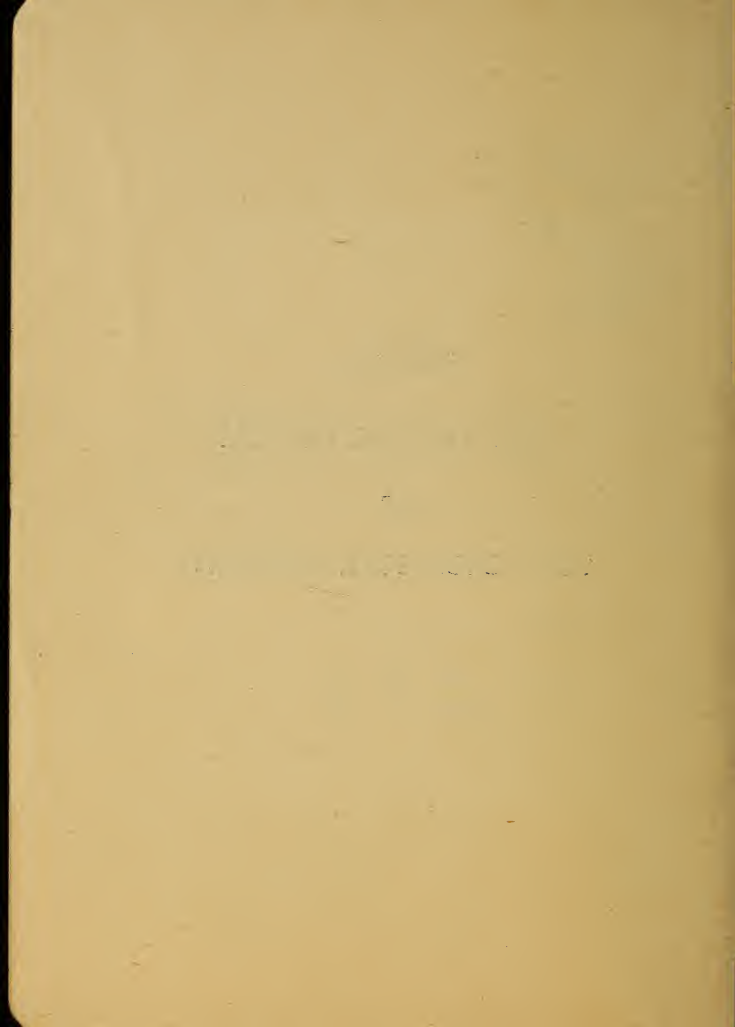
R.V.S. 2/13/22

SECTION I

COST KEEPING SYSTEM

OF

THE ELECTRICAL DIVISION



## COST-KEEPING SYSTEM.

### CLASSIFICATION.

A—Hydro-electric Power Plants.....	All districts.
B—Steam Electric Plants.....	Balboa District.
C—Transformer Substations.....	Cristobal District.
D—Transmission Lines.	
E—Distribution Lines.....	Transmission District Gatun Underground.
F—House Lighting System.	
G—Street Lighting System.....	Gatun District.
H—Spillways.....	Hydro District.
I—Freight Handling Cranes.	
J—General Expense.....	Transmission District, Cristobal-Gatun.
K—Intermediate Expense.....	Transmission District, Gatun-Miraflores.
L—.....	Transmission District, Miraflores-Balboa.
M—.....	Miraflores District.

This schedule shows the composition of the symbols by which charges will be made; the first column showing the general classification of expenditures, and the second column showing the location. As an example: "C" represents transformer substations and "G" represents

(in second column) Gatun, so that "CG" is the symbol for the Gatun transformer substation.

The classifications of "General Expense" and "Intermediate Expense" will be used only by the Cost Accountant.

R—Telegraph System.

S—Railway Signal System.

T—Telephone System.

U—Fire Alarm System.

The last four accounts are not divided into districts and the location need not be shown.

Transmission lines include the 6,600-volt underground lines from the hydroelectric station to the Gatun substation and the 44,000-volt lines from Cristobal to Balboa.

Distribution lines include all lines feeding directly to the consumer from the six substations or from the power stations. They may be either overhead or underground.

For cost-accounting purposes, the Darien and Gamboa substations are considered as being in the Miraflores district.

House-lighting systems are considered as beginning at the service entrance to the building.



## SUBACCOUNTS.

### POWER PLANTS.

Account No.	Name.
1.	Operating Labor—Mechanical.
2.	Operating Labor—Electrical.
3.	Fuel.
4.	Water.
5.	Lubricants.
6.	Miscellaneous Supplies and Expenses.
7.	Equipment Repairs—Mechanical.
8.	Equipment Repairs—Electrical.
9.	Structural Repairs.
10.	Equipment—Depreciation.
11.	Structures—Depreciation.
19.	General Expense.

### TRANSFORMER SUBSTATIONS.

- 20. Operation.
- 21. Equipment—Repairs.
- 22. Structures—Repairs.
- 23. Equipment—Depreciation.
- 24. Structures—Depreciation.
- 29. General Expense.

## TRANSMISSION LINES.

Account No.	Name.
30.	Supervision, Inspecting, and Testing.
31.	Maintenance and Repairs.
32.	Depreciation.
39.	General Expense.

## DISTRIBUTION LINES.

40.	Supervision, Inspecting, and Testing.
41.	Maintenance and Repairs.
42.	Depreciation.
49.	General Expense.

## HOUSE-LIGHTING SYSTEM.

50.	Supervision.
51.	Lamp Renewals.
52.	Miscellaneous.
59.	General Expense.

## STREET-LIGHTING SYSTEM.

60.	Supervision.
61.	Lamp Renewals.
62.	Miscellaneous.
69.	General Expense.

## SPILLWAYS.

Account  
No.

Name.

70. Operation.

71-A. Maintenance of Operating Machinery and Equipment.

71-B. Maintenance of Gates and Caissons.

71-C. Maintenance of Structure.

## FREIGHT-HANDLING CRANES.

80. Operation.

81. Maintenance and Repairs.

89. General Expense.

## TELEGRAPH SYSTEM.

400. Operation.

401. Maintenance of Duct Lines.

402. Maintenance of Underground Cables.

403. Maintenance of Overhead Wires and Cables.

404. Maintenance of Telegraph Equipment.

405. Maintenance of Clocks and Clock Circuits.

407. Miscellaneous.

408. Depreciation.

409. General Expense.

410. Stock Account.

## RAILWAY SIGNAL SYSTEM.

Account No.	Name.
500.	Operation.
501.	Maintenance of Duct Lines.
502.	Maintenance of Underground Cables.
503.	Maintenance of Overhead Wires and Cables.
504.	Maintenance of Interlocking Plants.
505.	Maintenance of Railway Signals and Appurtenances.
507.	Miscellaneous.
508.	Depreciation.
509.	General Expense.
510.	Stock Account.

## TELEPHONE SYSTEM.

600.	Operation.
601.	Maintenance of Duct Lines.
602.	Maintenance of Underground Cables.
603.	Maintenance of Overhead Wires and Cables.
604.	Maintenance of Exchange Equipment.
605.	Maintenance of Subscribers' Exchange Equipment.
607.	Miscellaneous.
608.	Depreciation.
609.	General Expense.
610.	Stock Account.
611.	Telephone Instruments (all instruments remain under this account while in the division).

## FIRE ALARM SYSTEM.

Account No.	Name.
----------------	-------

- |      |                          |
|------|--------------------------|
| 700. | Operation.               |
| 701. | Maintenance and Repairs. |
| 708. | Depreciation.            |
| 709. | General Expense.         |

## GENERAL EXPENSE.

- |     |   |
|-----|---|
| 90. | Superintendence.                          |
| 91. | Clerical.                                 |
| 92. | Drafting.                                 |
| 93. | Inspecting and Testing.                   |
| 94. | Gratuity Pay.                             |
| 95. | Office Supplies and Expenses.             |
| 96. | Miscellaneous.                            |
| 97. | Shop Expense (Building No. 9, shop only). |

## INTERMEDIATE EXPENSE.

- |      |                               |
|------|-------------------------------|
| 100. | Superintendence.              |
| 101. | Clerical.                     |
| 102. | Office Supplies and Expenses. |

## STOCK ACCOUNTS.

- |        |   |
|--------|---|
| E-4.   | Electrical Stock, Northern District.    |
| E-5.   | Electrical Stock, Southern District.    |
| E-6.   | Electrical Stock, Armature Repair Shop. |
| E-7.   | Instrument Repair Shop.                 |
| R-410. | Telegraph Stock.                        |
| S-510. | Signal Stock (railway).                 |
| T-610. | Telephone Stock.                        |

## DEFINITION OF ACCOUNTS.

*Operation.*—To operating account numbers shall be charged all labor (on distribution books) and all material (on foreman's orders, inspection calls, and invoices) used in the operation of any of the above systems or units of a system. In operation are included all materials that are regularly and necessarily consumed in the operation of the system and the labor involved in their handling.

*Supervision, Inspecting, and Testing.*—To these accounts shall be charged the wages of supervisors, foremen, inspectors, electricians, wiremen, and helpers, and all other labor engaged in inspecting and testing; and also any material and supplies used in making such inspection and tests.

*Maintenance and Repairs.*—To this account shall be charged all labor of foremen, wiremen, electricians, inspectors, etc., and helpers expended on the maintenance and repairs of the above systems or units of a system, and all material and miscellaneous supplies used in making such repairs. Where this account is divided between equipment and structures, equipment repairs shall include repairs to machines, switchboards, and all equipment, *i. e.*, all parts which pertain to the system but which are not a part of the building or structure itself. Structural repairs include repairs to doors, windows, roofs, partitions, floors, grounds, walks, paving, gutters, sewers, drainage, toilets, racks, shelving, etc. (In case a reserve for repairs is authorized, the monthly charge to this account will be an estimated amount furnished by the Auditor and the actual cost of repairs will be charged to the Reserve Account.)

*Lamp Renewals.*—To this account will be charged all lamps used in renewing burned-out lamps in quarters, shops, offices, army posts, and other places where the cost of lighting current includes lamp renewals. It also covers the labor of making replacements. It will be credited with any amount recovered from the sale of burned-out lamps.

*Depreciation.*—The charge to this account will be the estimated monthly depreciation, which amount will be determined by the Auditor. This estimated charge will be credited to a Reserve Account, to which will be charged the cost of replacing the system or unit in question when worn out or otherwise retired from service.

*Other Expense.*—To this account will be charged a proportion of all general and intermediate expense of the Electrical Division, as shown by symbols "J" and "K." This account is handled in the Cost Accountant's office and it is unnecessary to go into detail regarding it here.

*Miscellaneous.*—To this account will be charged any miscellaneous expense which can not be located direct to any other classified account and which has not otherwise been provided for. Under House Lighting Accounts, this shall include labor and material used in renewing or changing wiring, fuses, rosettes, sockets, switches, and other lighting fixtures in building. It will also include repairs to cords and plugs only for electrical heating appliances, motors, or stand lamps, which are the personal property of an employee occupying quarters, and who has had such appliance, motor or lamp installed by the Electrical Division. It shall not include any repairs to the appliance itself, nor any new heating elements or other parts except

as above mentioned. Such work must be paid for by the owner of the appliance, and if done by the Electrical Division, the work must be covered by a work order, hereinafter described.

*Stock Account.*—In those units of the Electrical Division which are regularly engaged in construction work for this and other departments and divisions of The Panama Canal and others, it is necessary to carry a stock of material, the ultimate use for which is not known at the time it is drawn from the Supply Department store. It is, therefore, impossible to show the account to which it will ultimately be charged, on the foreman's order at the time it is drawn. To obviate this difficulty, certain stock accounts are set up. When the material is finally used on a job, this stock account must be credited, proper forms being supplied for that purpose. This account is not to be used in drawing material when the account number or work order number on which the material is to be actually expended is known.

Work in the Telephone and Telegraph Department will be classified and handled as follows:

A—Troubles: 1. Cable. 2. Line. 3. Instrument.

B—Moves: 1. Commercial. 2. Other than Commercial.

C—Installation of new telephones.

D—Removal of telephones.

E—Regular Maintenance and Construction.

If more than one work card (PC 1507-a) is issued for the same class of work, notation should be made as to which will take precedence.



After a card has been issued to a foreman, inspector, or cable splicer covering certain work, they will keep the wire chief or general foreman informed as to its progress. Any undue delay in completing work is to be reported to the Supervisor of Telephones by the wire chief or the general foreman, who will be held responsible for delays if not reported.

#### ELECTRICAL DIVISION WORK ORDERS.

The foregoing cost accounting system applies to the operation and maintenance of the various units of the Electrical Division only. All work done for other departments of The Panama Canal or the Government, or for employees, outsiders, contractors, etc., must be covered by an *Electrical Division Work Order*. Each work order is numbered, a consecutive series of numbers being used, with a letter prefix. The letter "E" is used for all work other than that pertaining to Telephones, Telegraphs, or Signals. For these the letter "T" is used. Work orders are sometimes issued for work done within the division when it is desired to keep a separate cost of the job, and in the case of all construction work. *Work orders are issued only from the Electrical Engineer's Office*. Proper authority must be secured for every work order issued. When necessity demands that work be performed previous to the issuance of the work order covering it, the work order number may be telephoned to the field for immediate use.

Arrangements are made with most departments and divisions whereby blanket work requests covering jobs costing \$50 or less are issued at the beginning of each fiscal

year and which constitute authority for such jobs to be performed in the field upon receipt of form PC 431 signed by foremen or others authorized to sign. The numbers of the Electrical Division blanket work requests on other departments and divisions, and also the number of the blanket work requests of other departments and divisions on the Electrical Division, will be sent to the field at the beginning of each fiscal year, or will be given from the office on request. *No blanket work orders are issued for work done by the telephone or signal department;* a separate work order being issued for each job.

When a work order is issued on the electrical repair shop the suffix 'S' will be added to the work order number in order that a shop expense charge may be added to such work.

Work orders covering the transfer of electrical appliances or telephones from one house to another should be given preference over new installations, except in cases where new installations are marked "*Rush*." The word "*Rush*" is used only when considered necessary for the exigencies of the service.

#### COMPLETION REPORTS.

Upon the completion of a work order a completion report (Form PC 723-1) must be returned to the Electrical Engineer's office in duplicate, together with a wiring memorandum (Form PC 730) or a diversion report (Form PC 1524), also in duplicate, showing the material used from stock (that is, any material which was not drawn directly from a Supply Department storehouse on foremen's order and charged directly to the job). These forms are so made

as to clearly indicate their use and need no explanation here. (See facsimiles of forms elsewhere in this book.) These completion reports must be made out in *detail*, covering all points set forth therein which are applicable to the job in question.

All completion reports on wiring and lighting jobs in all quarters will be so arranged as to show the light inventory of each apartment and not of the house as a whole. This is necessary in order to correct and maintain our records upon which flat rate electric light charges are based.

#### DIVERSION REPORTS.

When it is desired to transfer any material from one account number or work order number to another account number or work order number, a diversion report is to be used. (NOTE.—Wiring memorandums, Form PC 730, are one form of diversion report.) These must be sent to the Electrical Engineer's office in duplicate.

#### FREIGHT BILLS.

When signing freight bills, please arrange to write on face of bill the account number or work order number to which material on this bill is to be charged, insofar as it is possible to do.

*Blanket Work Requests of Electrical Division on Other Divisions for 1916-17.*

- OME-3313. Building Division.
- OME-3311. Lock Operation.
- OME-3310. Mechanical Division.
- OME-3312. Municipal Division.
- OME-3518. Panama Railroad.
- OME-3314. Supply Department.

*Blanket Work Orders by Other Divisions on Electrical Division for 1916-17.*

- E-4042. Accounting Department, Auditor, Paymaster, and Collector..... A-3270
- E-4007. Army, Engineers Office, U. S. Troops, Canal Zone..... Z-3377
- E-4026. Army, 29th Infantry, W. M., Camp Gaillard..... Z-3380
- E-4027. Army, C. A. C., Q. M., Cristobal..... Z-3386
- E-4028. Army, C. A. C., Q. M., Fort Grant..... Z-3383
- E-4024. Building Division..... B-3274
- E-4036. Clubs and Playgrounds, all Y. M. C. A. Secretaries..... E-3286
- E-4000. Dredging Division, Miscellaneous repairs, renewals, etc., to light and power lines..... DD-6849
- E-4002. Dredging Division, repairs to sand cranes, Gamboa Gravel Plant..... DD-6845
- E-4003. Dredging Division, repairs to *Ajax* and *Hercules*..... DD-6846

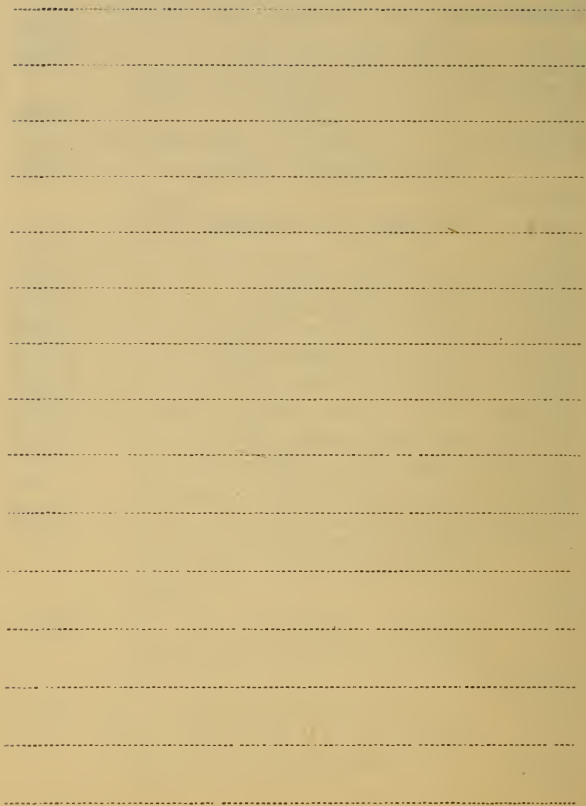
E-4004.	Dredging Division, repairs to floating equipment.....	DD-6842
E-4005.	Dredging Division, repairs to relay pumps, Paraiso.....	DD-6844
E-4006.	Dredging Division, repairs to relay pumps, Balboa.....	DD-6843
E-4020.	Executive, Administration Building.....	E-3283
E-4021.	Executive, Civil Affairs, Schools, Posts. Police and Fire, District and Magistrates Courts.....	E-3279
E-4035.	Fortifications.....	OMF-3315
E-4025.	Health Department.....	H-3293
E-4052.	Marine Department, Port Captain, Balboa.....	OMM-3317
E-4051.	Marine Department, Port Captain, Cristobal.....	OMM-3317
E-4053.	Marine Department, Lighthouse Division.....	OMM-3317
E-4047.	Mechanical Division, Balboa Shops.....	M-297
E-4049.	Mechanical Division, Mt. Hope Shops...	M-297
E-4048.	Mechanical Division, Paraiso Shops.....	M-297
E-4050.	Mechanical Division, Roundhouse, Cristobal.....	M-297
E-4023.	Municipal Engineering Division.....	ME-3296
E-4044.	Navy Submarines.....	Z-3946
E-4045.	Naval Radio, Darien, Balboa, and Colon	Z-3449
E-4033.	Naval Radio Station, Darien, inspect oil switches, test oil and renew oil when necessary and do other work in transformer house at Darien when necessary.....	Z-3395

E-4041. O. & M., Atlantic Locks .....	OM-3308
E-4008. O. & M., Pacific Locks.....	OMPL-65
E-4043. O. & M., Coaling Plant, Cristobal.....	P-674
E-4034. O. & M., Engineers Office, Embree, Willson and Malsbury .....	OM-3305
E-4011. O. & M., East Breakwater.....	TCA-404
E-4009. O. & M., Pacific Terminals.....	TCB-558
E-4010. O. & M., Pacific Terminals, Berm Cranes.....	TCB-562
E-4016. P. R. R., Superintendent's Office .....	P-657
E-4017. P. R. R., R. & F. Agent, Balboa .....	P-649
E-4019. P. R. R., R. & F. Agent, Colon.....	P-647
E-4012. P. R. R., Superintendent of B. & B .....	P-664
E-4014. P. R. R., Engineer of Docks .....	P-651
E-4013. P. R. R., Masonic Temple, Cristobal....	P-654
E-4015. P. R. R., S. S. Line.....	P-656
E-4018. P. R. R., Roadmaster.....	P-642
E-4046. P. R. R., Care and maintenance of elec- tric coal handling machinery at Cristobal Docks.....	P-690
E-4038. P. R. R., Maintenance and charging of storage batteries, trucks, etc., at Cris- tobal Docks. Estimated at \$200 per month.....	P-658
E-4057. P. R. R., Commissaries, Laundries, Warehouse, Cold Storage, Bakeries, etc.....	P-657
E-4058. P. R. R., Hotel Washington.....	P-657
E-4055. Supply Department, D. Q. M. offices, shops, corrals, quarters, etc.....	S-3355

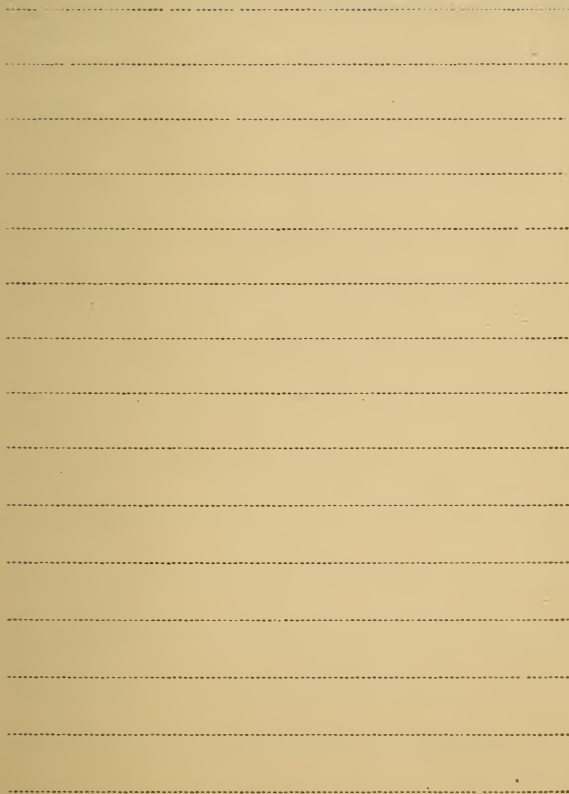
E-4056. Subsistence Department, line hotels and Tivoli.....	S-3355
E-4032 Pacific Mail Steamship Co.....	Z-3388
E-4031 Pacific Steam Navigation Co., author- ized by Mr. Lambert.....	Z-3387
E-4030 Panama Agencies Co., authorized by agent of company at Balboa.....	Z-3390

*United Fruit Co., Telephone System.*

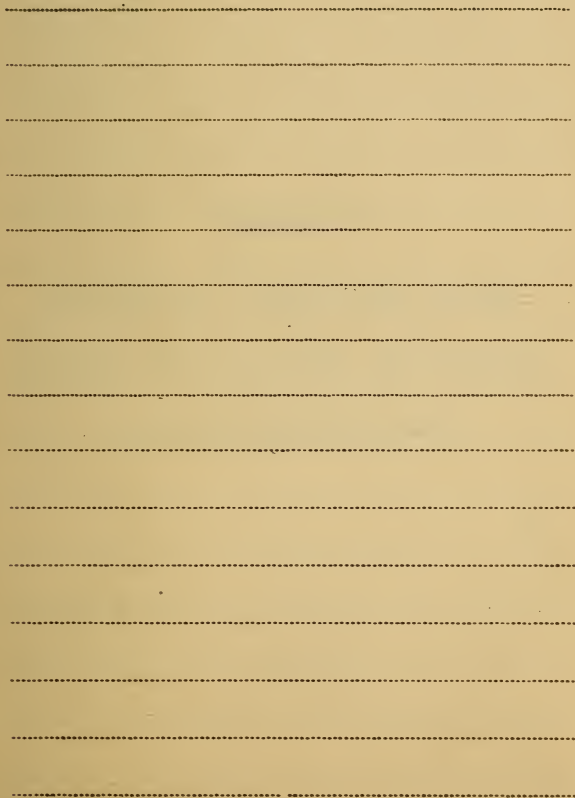
T-51088. Month of July, 1916.....	Z-3543
T-51089. Month of August, 1916.....	Z-3543
T-51091. Month of October, 1916.....	Z-3543
T-51092. Month of November, 1916.....	Z-3543
T-51093. Month of December, 1916.....	Z-3543
T-51094. Month of January, 1917.....	Z-3543
T-51095. Month of February, 1917.....	Z-3543
T-51096. Month of March, 1917.....	Z-3543
T-51097. Month of April, 1917.....	Z-3543
T-51098. Month of May, 1917.....	Z-3543
T-51099. Month of June, 1917.....	Z-3543







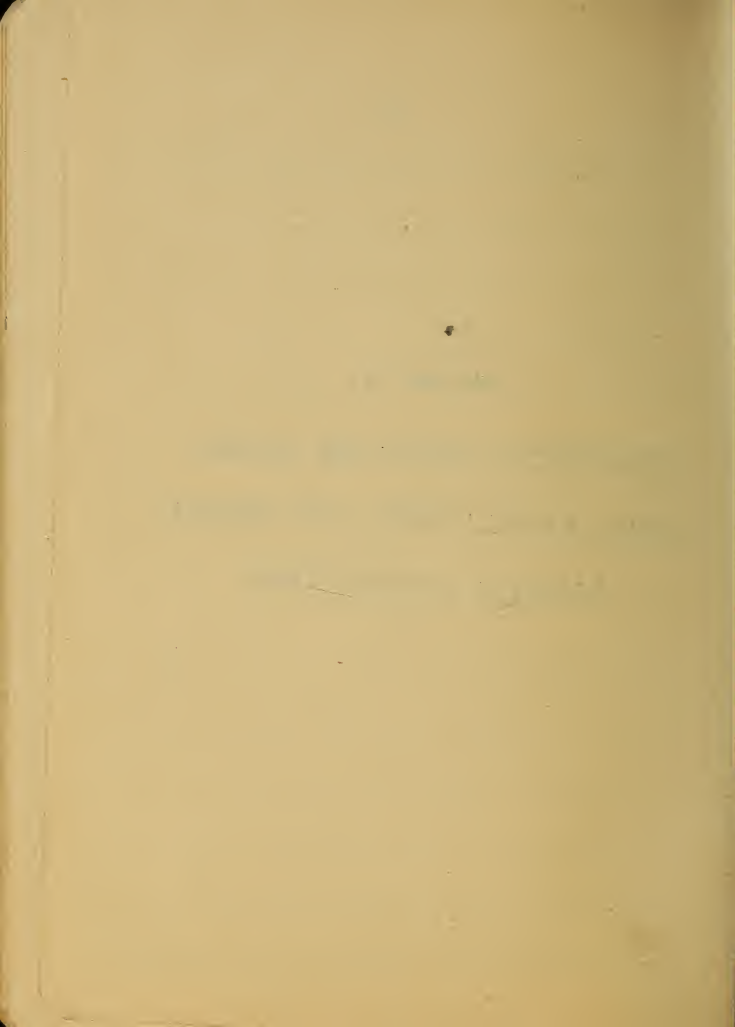






## **SECTION II**

# **ELECTRICAL CIRCULARS, RATES, FORMS, REGULATIONS, AND MISCEL- LANEOUS INFORMATION**



## I.

BALBOA HEIGHTS, *June 12, 1916.*

Circular No. 676-8.

## CHARGES FOR ELECTRIC CURRENT.

The rate for electric current furnished to individuals (nonemployees) and companies in the Canal Zone, and to employees of The Panama Canal and Panama Railroad Company for commercial use, as prescribed in Circular 676-5, is hereby amended, effective July 1, 1916, as follows:

*Current consumption in one month.*

First 100 K. W. H .....	\$0. 08 per K. W. H.
Next 200 K. W. H .....	. 06 per K. W. H.
Over 300 K. W. H .....	. 04 per K. W. H.

CHESTER HARDING,  
*Acting Governor.*

## II.

BALBOA HEIGHTS, *August 4, 1915.*

Circular No. 676-6.

ELECTRICAL APPLIANCES OR CHANGES IN WIRING IN QUARTERS.

1. Occupants of buildings belonging to The Panama Canal and Panama Railroad Company are hereby forbidden to make any addition or change whatsoever in the electrical wiring in their apartments, or to use electrical appliances of any kind whatsoever, without first obtaining the necessary authority from the office of the Electrical Engineer.

2. Applications for the use of electrical appliances or requests for additions or alterations of any kind to electrical systems should be made direct to the Electrical Engineer and not to the District Quartermaster.

CHESTER HARDING,  
*Acting Governor.*



## III.

BALBOA HEIGHTS, C. Z., *August 5, 1916.*

Circular No. 627-15.

QUARTERS, FUEL, AND ELECTRIC CURRENT FOR EMPLOYEES  
ON THE GOLD ROLL AND FOR AMERICAN  
CITIZENS ON THE SILVER ROLL.

That part of above circular which applies to the use  
of electric current in quarters is as follows:

\* \* \* \* \*

*Electric Current.*

34. (a) Electric current for lighting and for such electrical appliances as are installed in conformity with the following regulations will be furnished free of charge to employees on the gold roll and American citizens on the silver roll of The Panama Canal and the Panama Railroad Company on the Isthmus of Panama.

(b) No alterations nor additions to electric circuits in quarters as installed by the Electrical Division or any other department or division of The Panama Canal or the Panama Railroad Company will be made except by the Electrical Division on written application to the Electrical Engineer. This applies to changes in number, location or size of lights; use of extension cords; use of electrical

appliances such as irons, fans, hot plates, toasters, percolators, etc., and to all alterations or additions whatsoever.

(c) A charge will be made against employees for the installation of any additional outlets, changes of circuits or other work that may, in the judgment of the Electrical Engineer, be necessary for the use of electrical appliances. This charge will be fixed by the Governor on the recommendation of the Electrical Engineer. Payment will be made to the Collector, upon notification by the Electrical Division that additional outlet is necessary. Applications for the use of irons, fans, hot plates, toasters, or other electrical appliances shall be made on form obtained from the Electrical Engineer. No electrical appliance will be used until the installation is approved by the Electrical Division. A record of all appliances whose use is approved, whether or not a special installation is necessary, will be kept by the Electrical Division.

(d) The Electrical Division will, from time to time, make such inspections of quarters as may be necessary to see that these regulations are complied with.

(e) The use of electrical appliances for which authority has already been obtained under existing regulations, may be continued without further authority.

\* \* \* \* \*

CHESTER HARDING,  
*Acting Governor.*

## IV.

INSTRUCTIONS TO ELECTRICAL DIVISION EMPLOYEES RE-  
GARDING THE INSTALLATION, REMOVAL, AND  
TRANSFER OF ELECTRICAL APPLIANCES  
USED BY EMPLOYEES IN QUAR-  
TERS OF THE PANAMA  
CANAL.

Effective July 1, 1916, the monthly charges for current used for electric appliances by gold employees in quarters, is discontinued and no further charges of this kind will be made, in conformity to Governor's Circular 627-15.

It will therefore be necessary to charge for installing new outlets. It will also be necessary to keep a record of all electrical appliances in use, their transfer from one house to another, etc., in order to check the load on our feeders and distributing transformers, as in the past. The following method is outlined for your guidance:

1. Employees shall make written application to the Electrical Division covering each appliance they desire to use, on a form provided for this purpose.

2. They shall notify the Electrical Division in writing when they desire to transfer their appliances from one house to another, on the above-mentioned form.

3. They shall in no case connect appliances having a consumption of more than 250 watts to a lamp socket or lamp receptacle, but shall connect it to the heater receptacles, such as the Hubbell or Chapman wall receptacles rated at 10 amperes, 250 volts, which are used for this

purpose. Larger receptacles must of course be installed for large appliances, such as ranges, etc.

4. Receptacles will not be removed or disconnected when a transfer is made or when the use of an appliance is discontinued.

5. More than one appliance may be used successively in the same receptacle, provided that none of them exceed the rated current carrying capacity of the receptacle.

6. If the house or apartment is not wired for a suitable receptacle, or if the occupant desires an additional receptacle, a charge of \$2.50 U. S. C. will be made. This charge is based on the average labor charges only of several hundred previous installations and does not include the cost of material, which remains the property of The Panama Canal and upon installation becomes part of the house wiring and is not to be removed.

7. If the house is already provided with a suitable receptacle or if a receptacle has been installed and later removed, leaving all wiring, molding or conduit, etc., in place so that receptacle may be readily attached with a few minutes' work, no charge will be made. No charge will be made for putting Hubbell caps or Chapman plugs, etc., on cords to fit the receptacles installed.

8. Repairs to appliances will be limited to the renewal of worn-out cords, and to simple adjustments which can be readily made on the premises. Any extensive repair work shall be sent to the shop and a work order issued to cover, the cost being charged to the owner.

9. Employees will be instructed to send their written applications direct to the Electrical Division field offices in the several towns and districts. All applications re-

ceived by the Electrical Engineer will be sent to the field. Upon receipt of these applications the field forces will inspect the wiring of the apartment and if a receptacle is already installed, or can readily be connected as provided in paragraph 7, they will make necessary changes to the cord to fit the receptacle and report the installation as complete on an inventory card, at the same time making the necessary addition to the inventory card in the house, which is described in paragraph 11. In this case no work order will be issued, the time being charged to the maintenance of house lighting system.

10. If a new receptacle is to be installed, as provided in paragraph 6, the application will be filled in by the wireman making the inspection, stating this fact, and will be left with the applicant who will forward it, together with \$2.50 to the Collector, The Panama Canal, in accordance with the instructions on the form. The Collector will receipt the application and forward to the Electrical Engineer promptly, when a work order will be issued to cover the installation and a completion report made in the usual manner.

11. A card will be made to be tacked up in each apartment in the panel box or other convenient place. This card will contain Circular 676-6, and a space for entering the inventory of lights and receptacles in the house. These cards will be revised whenever any additional lights, receptacles, etc., are installed and will serve as a check to the district wireman and a reminder to the occupant of the quarters to report additions, removals, etc.

12. Inspections of quarters from time to time for the purpose of insuring that these regulations are complied with will be made as directed by the Electrical Engineer.

W. H. ROSE,  
*Electrical Engineer.*

## V.

### DRY CLOSET LAMPS.

All *dry closet lamps* must be protected with a wire lamp guard of ample size to prevent clothing from coming in contact with the lamp.

## VI.

### RECOVERY OF LAMPS.

All burned-out Mazda lamps, nitrogen series, carbon, or other wire-drawn lamps have a market value, as bases are sold as scrap brass and considerable platinum is recovered. All such lamps should be collected and turned in to Obsolete Store, Mt. Hope, from time to time in order that they may be returned to the States, where they find a ready market.

*All employees are requested to save burned-out lamps in quarters and elsewhere and turn them over to employees of the Electrical Division when renewals are made.*

## VII.

## DEFACING WOODWORK IN FINISHED BUILDINGS.

Employees must be careful when making installations or changes in buildings not to deface the woodwork by leaving dirty finger marks on the paint.

## VIII.

## USE OF GASOLINE TORCHES.

Employees must use great care in the use of gasoline torches and furnaces to prevent fires in buildings and also to prevent injury to employees through the improper or careless use of this class of equipment.

## IX.

## CABLE SPLICING STRICTLY JOURNEYMEN'S WORK.

The making of splices and soldering, taping, and stowing of same in outlet boxes or condulets is strictly journeyman's work and is not to be performed by helpers.

Careless work on joints and taping causes most of our trouble and soon shows up. Journeymen wiremen will be held strictly responsible for any defective work of this nature, and when same is discovered, either by tests or in actual service, the wireman responsible for it will be sub-

ject to discipline. All splices on rubber-covered wire carrying 110 volts or more, which are to be stowed in conduits must be served with a thickness of rubber tape equal to the thickness of the rubber insulation on the wire. in addition to a serving of friction tape over all.

## X.

### WIRING RULES AND REGULATIONS.

All work in buildings of The Panama Canal should conform to the Rules and Requirements of the National Board of Fire Underwriters. Wiremen and other employees of the Electrical Division doing construction work, such as inside wiring, outside wiring, switchboard or power wiring, etc., should familiarize themselves with such portions of the above-mentioned rules as apply to their branch of work. Ignorance of these rules will not be accepted as an excuse for unsatisfactory work.

An exception to the Rules will be found in paragraph IV-3.

## XI.

### ARMY BUILDINGS.

In connection with work to be performed by employees of the Electrical Division in buildings assigned to the Army, the following instructions are issued:



Electrical power is billed to the Army at actual cost to The Panama Canal determined by the Cost Accountant from month to month as the average for all distribution districts, including the cost of maintenance of secondary distribution systems, house-lighting systems, and lamp renewals. They are in consequence entitled to everything in the way of labor and material necessary for the maintenance of house-lighting systems, doorbells, annunciators, etc., that are ordinarily expended in the maintenance of such systems in buildings of The Panama Canal.

At Camp Otis, Empire, and Gaillard, and Forts Grant, Sherman, and Randolph, the Army has agreed to maintain their own secondary distribution system beginning at the secondary side of the transformers, including house and street lighting systems, but excepting lamps for renewals, which will be supplied by The Panama Canal. The Electrical Division keeps a maintenance man on the west side of the Canal to look after the primary distribution system and transformers. This maintenance man, when not engaged in work on that part of the system that is maintained by The Panama Canal will render any advice or assistance to the Army that is requested by the electrician sergeants, Post Quartermasters, Commanding Officers, or their duly authorized representatives. He will not supply materials, except lamps to be used for renewals, for that part of the system the maintenance of which has been assumed by the Army. Electrical appliances, such as irons, toasters, etc., may be installed by the Army authorities at their own discretion since they bear the cost of installation themselves and the power consumed is registered on our meter. Similarly at Fort Grant, the Electrical

Division employees in the Ancon-Balboa District who may be called upon by the Army authorities for assistance or advice will respond promptly and help out in any way that they can, subject to the restrictions mentioned above for Camp Otis, Empire, and Gaillard. At Cristobal, Gatun, Corozal, Quarry Heights, and other points where the Army does not have Electrical Sergeants for the maintenance of their secondary systems, the Electrical Division will maintain these systems in all respects as is done with Panama Canal systems. With regard to electrical appliances such as stoves, toasters, flat irons, etc., the Electrical Division can not make these installations free of charge. In order to take care of such installations when desired by the Army, the Electrical Division will make installations of appliances on written requests to this office. No prior deposit with the Collector will be required. The actual cost to The Panama Canal will be determined after the work is done and billed to the party requesting the installation. No monthly charge will be made for the use of such appliances.

In cases where lack of funds prevents the Army authorities from calling on The Panama Canal for minor wiring and other electrical jobs in Army buildings that can be performed by enlisted men of the Army, the proper employees of the Electrical Division will, upon request of the military authorities give such advice as may be desired and will from time to time inspect the work and see that the rules and requirements of the National Board of Fire Underwriters are complied with. Upon completion they will make a final inspection and submit a written report to this office, copy of which will be sent from this office to

the Commanding Officer of the post concerned, giving a brief description of the work and location sufficient for identification, and a statement as to whether or not the installation as made by the Army complies with the rules and requirements above mentioned, and if not a detailed statement of defects and a statement as to whether or not they have been previously called to the attention of the Army authorities.

## XII.

### ELECTRICAL DIVISION FORMS.

PC No.

1531. Application for Use of Appliances in Gold Quarters.

1509. Cable Transfer.

723-1. Completion Report.

1514. Danger Card (large) for Substations.

1524. Diversion Report—Book Form.

1522. Insulator Trouble Report.

735-1. Inventory of Electric Lights (card).

1504-Rev. Inventory of Electric Lights (sheet).

1508. Lamp Renewal Report.

1518. Log Sheet, Gamboa.

731-Rev. Log Sheet, Hydroelectric Station.

1510. Log Sheet, Miraflores Steam Plant.

1502. Log Sheet, substations.

725. Meter Abstract, monthly.

1527. Meter Test Card.

734. Power Distribution, monthly.

- 1513. Signal Battery, individual cell reading and battery.
- 1516. Signal Operations, P. R. R.
- 1511. Signal Storage Battery Record.
- 1517. Signal Track Battery and Relay Record.
- 1523. Stock Card—Electrical Division, 8" x 10"
- 727. Switch Tag.
- 1519. Telephone Exchange Equipment, Appraisal of.
- 1520. Telephone Inside Material, Appraisal of.
- 1512-1. Telephone Outside Material, Appraisal of.
- 1515. Winding Specifications.
- 730. Wiring Memorandum—Electric.
- 730-a. Wiring Memorandum—Telephone.
- 1507. Work Card—Electric, for field use.
- 1507-a. Work Card—Telephone, for field use.
- 721. Work Order Card.

### SECTION III

## USEFUL TABLES

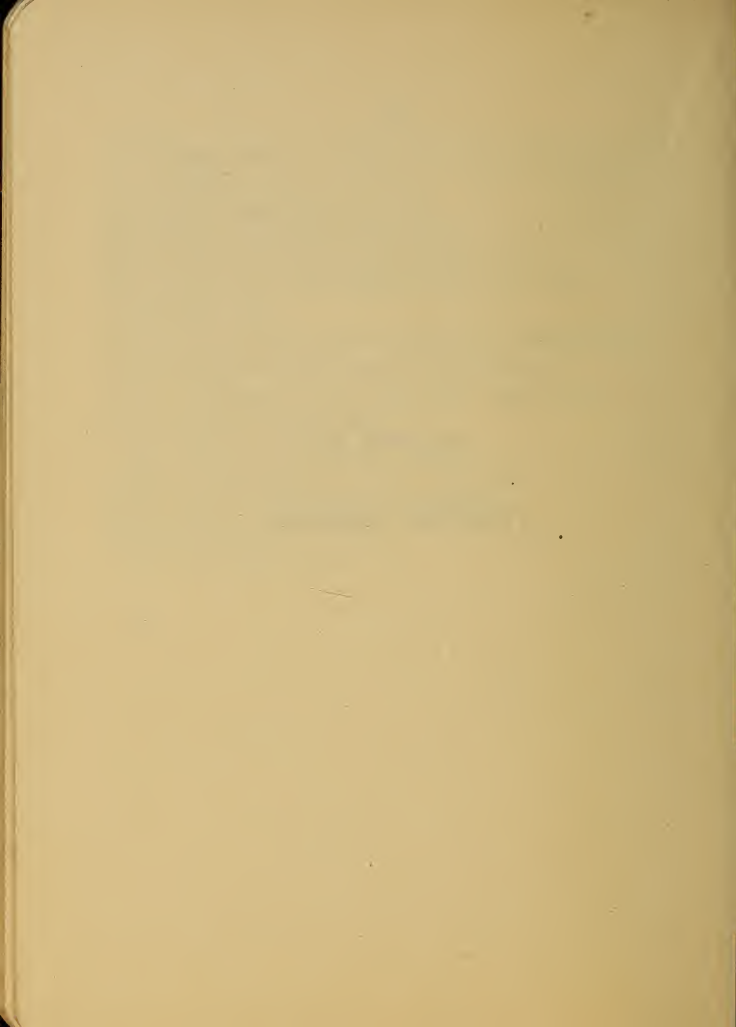


TABLE I.

## IRON CONDUIT.

*Sizes of standard insulated wire that can be pulled into various sizes of conduit.*

Rubber covered, double braids.	1-wire.	2-wire.	3-wire.	Rubber covered, 2 braids.	1-wire.	2-wire.	3-wire.
No. 14 B. & S.....	$1\frac{1}{2}$	$1\frac{1}{2}$	$3\frac{1}{2}$	1,100,000 c. m.....	$2\frac{1}{2}$	4	5
No. 12 B. & S.....	$1\frac{1}{2}$	$1\frac{1}{2}$	$3\frac{1}{2}$	1,200,000 c. m.....	$2\frac{1}{2}$	4	5
No. 10 B. & S.....	$1\frac{1}{2}$	$1\frac{1}{2}$	1	1,300,000 c. m.....	$2\frac{1}{2}$	$4\frac{1}{2}$	5
No. 8 B. & S.....	1	1	1	1,400,000 c. m.....	3	$4\frac{1}{2}$	6
No. 6 B. & S.....	1	$1\frac{1}{4}$	$1\frac{1}{4}$	1,500,000 c. m.....	3	5	6
No. 5 B. & S.....	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	1,600,000 c. m.....	3	5	6
No. 4 B. & S.....	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$	1,700,000 c. m.....	3	5	6
No. 3 B. & S.....	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$	1,800,000 c. m.....	3	6	7
No. 2 B. & S.....	$1\frac{1}{4}$	2	2	1,900,000 c. m.....	3	6	7
No. 1 B. & S.....	1	$1\frac{1}{2}$	2	2,000,000 c. m.....	3	6	7
No. 1-0.....	1	2	2	.....	.....	.....	.....
No. 2-0.....	1	2	2	.....	.....	.....	.....
No. 3-0.....	$1\frac{1}{2}$	2	$2\frac{1}{2}$	.....	.....	.....	.....
No. 4-0.....	$1\frac{1}{2}$	2	$2\frac{1}{2}$	.....	.....	.....	.....
200,000 c. m.....	$1\frac{1}{4}$	2	$2\frac{1}{2}$	.....	.....	.....	.....
250,000 c. m.....	$1\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	.....	.....	.....	.....
300,000 c. m.....	$1\frac{1}{2}$	$2\frac{1}{2}$	3	.....	.....	.....	.....
350,000 c. m.....	$1\frac{1}{2}$	$2\frac{1}{2}$	3	1 No. 10 and 2 No. 14..	.....	$\frac{3}{4}$	.....
400,000 c. m.....	$1\frac{1}{2}$	3	3	1 No. 8 and 2 No. 12...	.....	1	.....
450,000 c. m.....	2	3	$3\frac{1}{2}$	1 No. 6 and 2 No. 10...	.....	1	.....
500,000 c. m.....	2	3	$3\frac{1}{2}$	1 No. 4 and 2 No. 8....	.....	$1\frac{1}{4}$	.....
550,000 c. m.....	2	$3\frac{1}{2}$	4	1 No. 3 and 2 No. 6....	.....	$1\frac{1}{4}$	.....
600,000 c. m.....	2	$3\frac{1}{2}$	4	1 No. 2 and 2 No. 6....	.....	$1\frac{1}{4}$	.....
700,000 c. m.....	2	$3\frac{1}{2}$	4	1 No. 1 and 2 No. 5....	.....	$1\frac{1}{2}$	.....
750,000 c. m.....	2	$3\frac{1}{2}$	4	1 No. 1-0 and 2 No. 4...	.....	$1\frac{1}{2}$	.....
800,000 c. m.....	2	$3\frac{1}{2}$	4	1 No. 2-0 and 2 No. 3...	.....	$1\frac{1}{2}$	.....
850,000 c. m.....	$2\frac{1}{2}$	4	4	1 No. 3-0 and 2 No. 2...	.....	2	.....
900,000 c. m.....	$2\frac{1}{2}$	4	$4\frac{1}{2}$	1 No. 4-0 and 2 No. 1...	.....	2	.....
950,000 c. m.....	$2\frac{1}{2}$	4	$4\frac{1}{2}$	.....	.....	.....	.....
1,000,000 c. m.....	$2\frac{1}{2}$	4	$4\frac{1}{2}$	.....	.....	.....	.....

TABLE II.

*Recommended power carrying capacity in kilowatts of delivered energy at 100 per cent power factor.*

*Three-conductor, three-phase cables.*

Size B.&S.G.	VOLTS.							
	1,100	2,200	3,300	4,000	6,600	11,000	13,200	22,000
	KILOWATTS.							
6	92	183	275	333	549	915	1,098	1,831
5	109	217	326	395	652	1,087	1,304	2,174
4	130	260	390	473	781	1,301	1,562	2,603
3	154	309	463	562	927	1,544	1,854	3,089
2	179	358	536	650	1,073	1,788	2,145	3,575
1	209	418	626	759	1,253	2,088	2,506	4,176
0	240	481	721	874	1,442	2,402	2,884	4,805
00	279	558	836	1,014	1,674	2,788	3,347	5,577
000	322	644	965	1,172	1,931	3,217	3,862	6,435
0000	372	744	1,115	1,352	2,231	3,717	4,462	7,435
250000	413	827	1,240	1,503	2,480	4,132	4,960	8,264

To reduce the above amounts from kilowatts to amperes, divide by 3.806. To find the carrying capacity at any power factor other than unity multiply values given in above table by the power factor of the delivered load.



TABLE III.

*Table of carrying capacity of wires.*

The following table, showing the allowable carrying capacity of copper wires and cable of 98 per cent conductivity, according to the standard adopted by the American Institute of Electrical Engineers, must be followed in placing interior conductors:

B. & S. gauge number.	Diameter of solid wire in mils.	Area in circular mils.	Table A, rubber insulation.	Table B, other insulation.
18.....	40.3	1,624	3	5
16.....	50.8	2,583	6	10
14.....	64.1	4,107	15	20
12.....	80.8	6,530	20	25
10.....	101.9	10,380	25	30
8.....	128.5	16,510	35	50
6.....	162.0	26,250	50	70
5.....	181.9	33,100	55	80
4.....	204.3	41,740	70	90
3.....	229.4	52,630	80	100
2.....	257.6	66,370	90	125
1.....	289.3	83,690	100	150
0.....	325.0	103,500	125	200
00.....	364.8	133,100	150	225
000.....	409.6	167,800	175	275
0000.....	460.0	209,000	200	300
		211,600	225	325
		300,000	275	400
		400,000	325	500
		500,000	400	600
		600,000	450	680
		700,000	500	760
		800,000	550	840
		900,000	600	920
		1,000,000	650	1,000
		1,100,000	690	1,080
		1,200,000	730	1,150
		1,300,000	770	1,220
		1,400,000	810	1,290
		1,500,000	850	1,360
		1,600,000	890	1,430
		1,700,000	930	1,490
		1,800,000	970	1,550
		1,900,000	1,010	1,610
		2,000,000	1,050	1,670

1 mil equals 0.001 inch.

TABLE IV.

*Amperes per phase per kilowatt, single phase circuits.*

Volts.	Power Factor			
	100 per cent.	90 per cent.	80 per cent.	70 per cent.
110.....	9.09	10.01	11.36	12.98
220.....	4.54	5.05	5.68	6.49
440.....	2.27	2.52	2.84	3.24
1100.....	0.909	1.01	1.136	1.298
2200.....	0.454	0.505	0.568	0.649

TABLE V.

*Amperes per kilowatt in each leg of a balanced 3-phase line.*

Power Factor.	Voltage between any two wires.					
	110	220	440	1,100	2,200	6,600
50.....	10.50	5.25	2.62	1.050	0.525	0.175
60.....	8.75	4.37	2.18	.875	.437	.146
70.....	7.50	3.75	1.87	.750	.375	.125
75.....	7.09	3.50	1.75	.709	.350	.117
80.....	6.56	3.28	1.64	.656	.328	.109
85.....	6.17	3.09	1.54	.617	.309	.103
90.....	5.83	2.91	1.46	.583	.291	.097
95.....	5.52	2.76	1.38	.552	.276	.092
100.....	5.25	2.63	1.31	.525	.263	.087

TABLE VI.

*Relations of voltage, current, and power that apply to any 3-wire 3-phase circuit either delta or star connected.*

Wherein  $I$  = line current in amperes (current in each wire),  $P$  = the power transmitted in watts,  $E$  = voltage across lines (between any two wires), and p. f. is the power factor of the circuit. ( $\sqrt{3} = 1.73$  approximately.)

For a noninductive load:

$$I = \frac{P}{E \times \sqrt{3}} = \frac{0.577 \times P}{E} \text{ or approximately } = \frac{0.58 \times P}{E}$$

$$E = \frac{P}{I \times \sqrt{3}} = \frac{0.577 \times P}{I} \text{ or approximately } = \frac{0.58 \times P}{I}$$

$$P = E \times I \times \sqrt{3} = 1.73 \times E \times I.$$

For an inductive load:

$$\text{p. f.} = \frac{P}{1.73 \times I \times E} = \frac{0.577 \times P}{I \times E} \text{ or approximately } = \frac{0.58 \times P}{I \times E}$$

$$E = \frac{P}{\text{p. f.} \times 1.73 \times I} = \frac{0.577 \times P}{\text{p. f.} \times I} \text{ or approximately } = \frac{0.58 \times P}{\text{p. f.} \times I}$$

$$I = \frac{P}{p. f. \times 1.73 \times E} = \frac{0.577 \times P}{p. f. \times E} \text{ or approximately } = \frac{0.58 \times P}{p. f. \times E}$$

$$P = 1.73 \times E \times I \times p. f.$$

## TABLE VII.

*To reduce square mils or square inches to circular mils or the reverse, use the following formulas:*

$$\text{Cir. mils} = \frac{\text{Sq. mils}}{0.7854}$$

$$\text{Sq. mils} = \text{cir. mils} \times 0.7854$$

$$\text{Cir. mils} = \frac{\text{Sq. in.}}{0.0000007854}$$

$$\text{Sq. in.} = \text{cir. mils} \times 0.0000007854$$

Example: The sectional area of a bus bar is 3" x  $\frac{1}{4}$ ". Find its area in circular mils.

$$\begin{aligned} \text{Cir. mils} &= \frac{\text{Sq. in.}}{0.0000007854} = \frac{3 \times \frac{1}{4}}{0.0000007854} = \frac{0.75}{0.0000007854} \\ &= 955,000 \end{aligned}$$

## TABLE VIII.

A *circular mil* is the area of a circle  $1/1000$  inch in diameter. A mil is  $1/1000$  of an inch. The areas of electrical conductors are usually measured in circular mils. Since the area of any figure varies as the square of its similar dimensions, the area of any circle can be expressed in circular mils by squaring its diameter expressed in thousandths. Thus, since  $3/8 = 375/1000 = 0.375$ , the area of a circle  $3/8$  inch in diameter would be  $375 \times 375 = 140,625$  circular mils. The area of a circle  $0.005$  inch diameter would be  $5 \times 5 = 25$  circular mils.

## TABLE IX.

*Watts, kilowatts, and horsepower.*

One horsepower equals 746 watts, therefore:

$$\text{h. p.} = \frac{\text{watts}}{746} = \text{watts} \times 0.001$$

$$\text{Watts} = \text{h. p.} \times 746$$

$$\text{h. p.} = \frac{\text{kilowatts}}{0.746} = \text{kw.} \times 1.43$$

$$\text{Kw.} = \text{h. p.} \times 0.746$$

TABLE X.

*Equivalent conductor areas.*

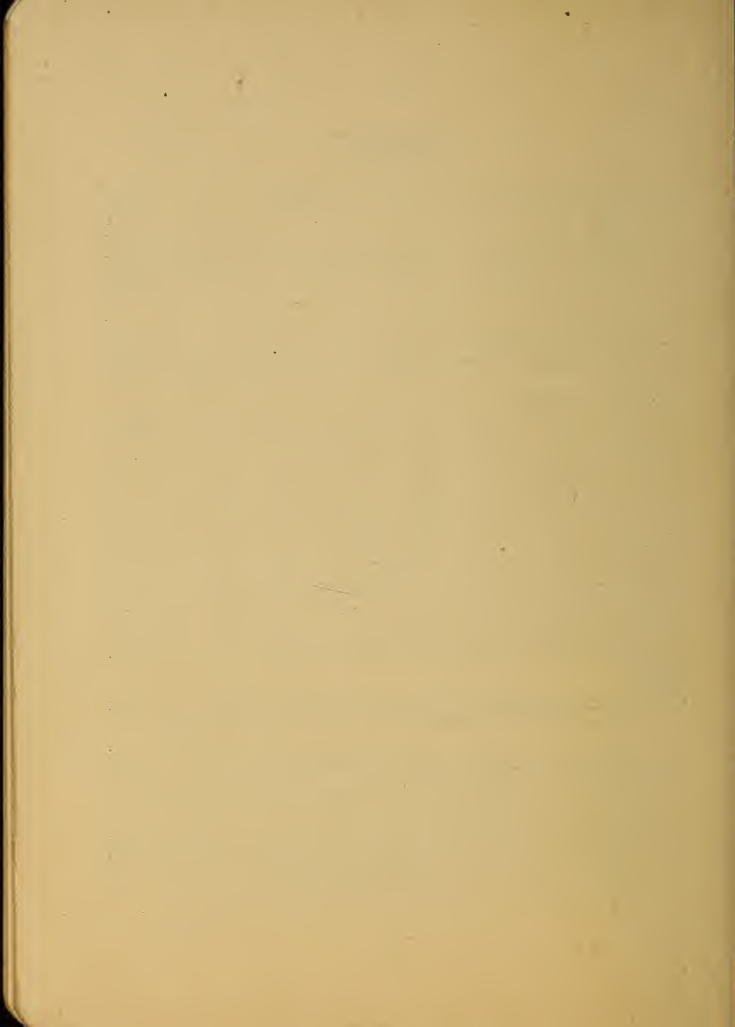
Of single conductor of any size, from 0000 to 15, in a stated number of smaller conductors.

B. & S. Gauge	In 2 conduc- tors.	In 4 conduc- tors.	In 8 conduc- tors.	In 16 conduc- tors.	In 32 conduc- tors.	In 64 conduc- tors.	In 2 conduc- tors, one of each.
No.	No.	No.	No.	No.	No.	No.	No.
0000	0	3	6	9	12	15	00 and 1
000	1	4	7	10	13	16	0 and 2
00	2	5	8	11	14	17	1 and 3
0	3	6	9	12	15	18	2 and 4
1	4	7	10	13	16	.....	3 and 5
2	5	8	11	14	17	.....	4 and 6
3	6	9	12	15	18	.....	5 and 7
4	7	10	13	16	.....	.....	6 and 8
5	8	11	14	17	.....	.....	7 and 9
6	9	12	15	18	.....	.....	8 and 10
7	10	13	16	.....	.....	.....	9 and 11
8	11	14	17	.....	.....	.....	10 and 12
9	12	15	18	.....	.....	.....	11 and 13
10	13	16	.....	.....	.....	.....	12 and 14
11	14	17	.....	.....	.....	.....	13 and 15
12	15	18	.....	.....	.....	.....	14 and 16
13	16	.....	.....	.....	.....	.....	15 and 17
14	17	.....	.....	.....	.....	.....	16 and 18
15	18	.....	.....	.....	.....	.....	.....

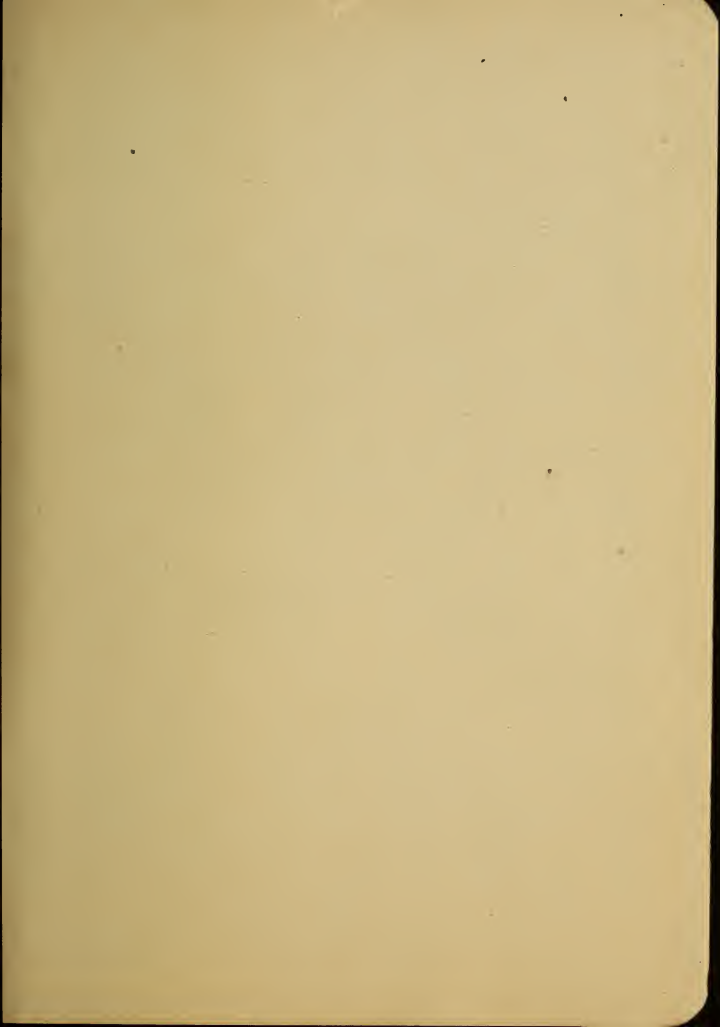
For the same temperature rise more current can be carried by using divided circuits and the greater number of divided circuits for the same equivalent cross section the greater the amount of current that can be carried. (See table of carrying capacities.)

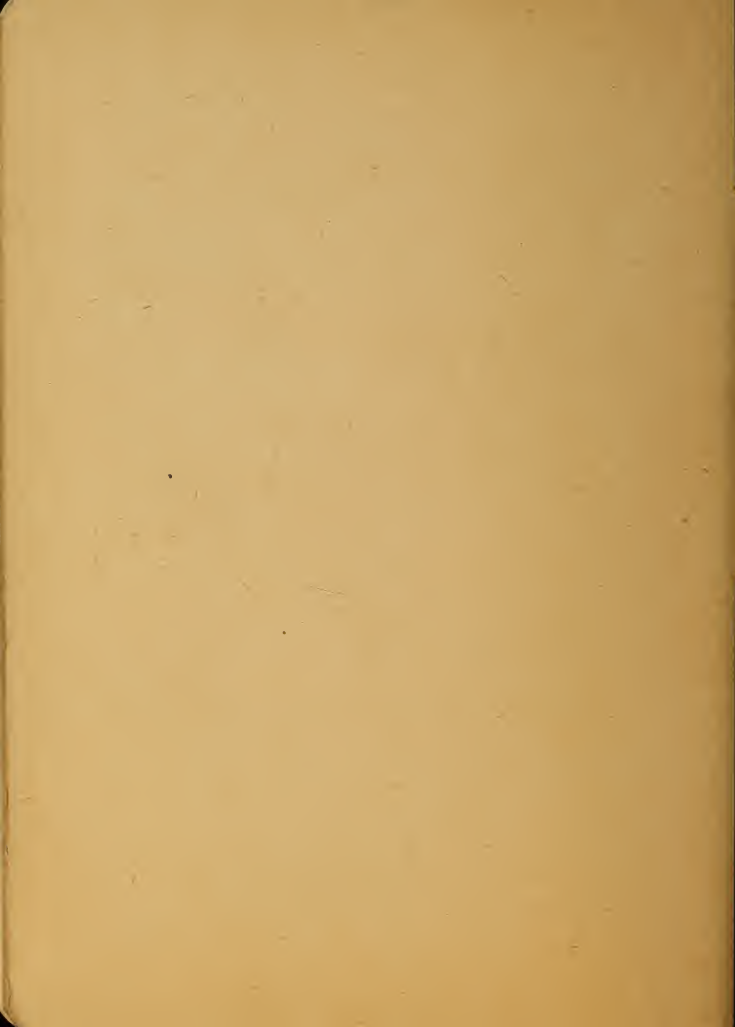
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